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Rozprawa doktorska

**Badanie właściwości cieplno-przepływowych nanopłynów na  
bazie CuO i Al<sub>2</sub>O<sub>3</sub> domieszkowanych wybranymi substancjami  
typu DRA**

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## **ABSTRACT**

Influence of DRA (drag reducing agents) additives on thermal and flow properties of nanofluids was investigated. The thesis has experimental character. Literature survey concerning nanofluids and its properties like density, viscosity, flow resistance, heat conduction as well as drag reduction phenomenon with particular reference to surface active agents influence on flow resistance was presented.

Investigated drag reducing agents were cetyltrimethylammonium chloride and sodium salicylate as well as oleylbis(2-hydroxyethyl)methylammonium chloride in the form of commercial product Ethoquad O/12, i.e. 75% w/w solution in 2-propanol, and sodium salicylate mixtures. Analyzed nanofluids were suspensions of commercially available copper(II) oxide of 30-50 nm diameter and  $\gamma$ -aluminum(III) oxide of 20-30 nm diameter nanoparticles. Investigated properties covered density, flow curves, zeta potential, flow resistance in pipelines of three diameters (4, 8 and 12 mm) and thermal conductivity of nanosuspensions. Influence of additives on thermal and flow properties of nanofluids was analyzed. Influence of surfactants concentration on drag reduction phenomenon in water and nanosuspensions was also investigated.

It was stated that DRA addition to CuO nanofluid had an influence on drag reduction. It was slightly smaller than in aqueous solutions of the same additives concentration. The highest drag reduction ca. 70% was achieved for the smallest investigated diameter, i.e. 4 mm. For larger diameters drag reduction decreased. Cationic surface active agents may also stabilize CuO nanofluid and therefore no other stabilizing agents were required. Addition of drag reducing agents to  $\gamma$ -Al<sub>2</sub>O<sub>3</sub> nanofluid did not improve its flow properties. Moreover, it caused destabilization of nanosuspension.

It was observed that addition of 1% vol. CuO and  $\gamma$ -Al<sub>2</sub>O<sub>3</sub> nanoparticles increased thermal conductivity of water by ca. 2-3%. Addition of DRA had no influence on thermal conductivity of nanosuspensions.

